NASA TECH BRIEF

Silicon Strain Sensors Enable Pressure Measurement at Cryogenic Temperatures

Diffused, heavily doped silicon strain-gage sensor elements have been developed for operation in pressure transducers over a wide temperature range. Optimization of gage characteristics, excitation-source impedance, bridge-circuit parameters, and transducer structure has led to the design of miniature pressure transducers which exhibit zero and sensitivity shifts of less than ±3 percent of full scale throughout the temperature range from +250° to −450°F (700°F temperature span). Small thermal mass combined with close coupling between a metallic diaphragm (force summing member) and sensor elements minimizes sensitivity to temperature transients. Silicon was selected as the most satisfactory semiconductor material from which to fabricate wide temperature range strain sensors for the following reasons: (1) Silicon offers the best combination of piezoresistive and mechanical properties of any known semiconductor material. (2) Silicon device processing techniques are well developed and readily adaptable to fabrication of miniature gage elements. (3) The piezoresistive behavior of silicon is sufficiently well known to permit prediction of gage characteristics on the basis of impurity type and concentration.

Although the sensors were specially developed for low-temperature operation, they perform equally well at much higher temperatures, thus providing continuous measurement capability over a 700°F temperature range.

Prototype pressure transducers (0.8-inch diameter × 1.1-inch length) incorporating the silicon sensor elements have met the following specifications:

Pressure Range: 0 to 2000 psig

Combined Nonlinearity and Hysteresis:
less than 1.1% F.S. above −320°F and less than 35% F.S. from −320°F to −450°F

Repeatability:
less than 1% F.S., except for one unit (of three) which indicated 9.5% at −446°F only

Compensated Temperature Range: −320° to +250°F

Temperature Effects within Specified Temperature Range:

0.321%/°F maximum from −108° to +250°F
2.2%/°F maximum from −320° +250°F
} Zero

0.064%/°F maximum from −320°F to +250°
0.074%/°F maximum from −446° to +250°F
} Full Range

Excitation: 10v

Output Voltage: 30 mv F.S. ±10% at 75°F

Frequency Response: 1000 Hz

Acceleration: 50 g, 200 to 3000 Hz

Accleration Effect:
less than 0.1% F.S./50 g or 0.002% F.S./1 g

Shock: 1000 g (1 ms duration with no damage)

Note:

Complete details may be obtained from:
Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B68-10262

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

Source: R. Bowman, J. Burns, and W. McLellan
of Electro-Optical Systems, Inc.
under contract to
Marshall Space Flight Center
(MFS-14703)

Category 01